



Cost-Benefit Analysis of Selected Gully Erosion Projects in Gombe Metropolis, Gombe State, Nigeria

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Abstract

This study analyzes the costs and benefits of selected gully erosion control projects in Gombe Metropolis, specifically the GSU-Mallam Inna-Kagarawal and FCE(T)-Jauro Abare-Jauro Kuna-M/Inna-Wuro Kesa-Tukulma gully sites. Data were collected from government agencies (State Ministry of Environment, NEWMAP) and local community members affected by the project. Using Microsoft Excel, the Net Present Value (NPV) and Benefit-Cost Ratio (BCR) were calculated to determine project viability. The results show that the GSU project had an NPV of -4,578,284 and a BCR of 0.85, indicating that costs exceeded benefits, making the project financially unviable. In contrast, the FCE(T) project had an NPV of 137,672,712.12 and a BCR of 1.80, demonstrating its economic feasibility. The study concludes that cost-benefit analysis (CBA) is a valuable tool for assessing erosion control projects and recommends that government agencies incorporate it into project planning.

Keywords: Cost, Benefits, Net present value, benefit cost ratio, analysis

JEL Classification:

Contribution to/Originality Knowledge

The study contributed to existing body of knowledge by establishing the link between economic analytical tool and gully erosion control planning to help policy makers make informed decision in the allocation of scarce resources to gully erosion control project having in mind cost-effectiveness of each control method and whether the control project is worthwhile or not base on the cost-benefit analysis introduced into the planning stage.

1.0 Introduction

In economic terms, controlling erosion using any method can only be worthwhile if the cost of control is less than the value of benefits accrued. This means that the economic definition of erosion is somewhat flexible than the physical definition, in which even a minor removal of soil can still be regarded as erosion, but if they have no appreciable impact on human activities then there is no economic value in their mitigation. (Haydones, et al., 2008).

analysing the cost and benefit of erosion especially gully erosion control project may allow for judicial allocation of resources and project implementation. Furthermore, economic analysis can allow for the comparison between different conservation technologies to assess the most efficient allocation of resources as well as balancing costs with effectiveness and financial benefits (Haydones, et al., 2008).

Cost-Benefit Analysis (CBA) is a policy assessment method that quantifies in monetary terms the value of all consequences of a policy to all members of society. More generally, Cost-benefit analysis applies to policies, programs, projects, regulations, demonstrations, and other

government interventions. The aggregate value of a policy is measured by its net social benefits, sometimes simply referred to as the net benefits. The Net Social Benefits (NSB), equal the social benefits, (B), minus the social costs (C), (Boardman & Vining, 2014).

The broad purpose of Cost-benefit Analysis is to help social decision making and to make it more rational. More specifically, the objective is to have more efficient allocation of society's limited resources. In the conduct of CBA, one must be able to demonstrate the effectiveness of one method of control over the other alternatives in terms of cost efficiency with higher benefits, (Boardman & Vining, 2014).

2.0 Literature Review

2.1 Economic Valuation of Cost and Benefit

Economic valuation is a tool used to quantify the costs and benefits of the gully erosion control project in monetary terms. Various methods have been developed to translate the benefits of the gully control project into monetary value. However, it is important to know that not all gully control costs and benefits can be valued in monetary units (Xiang 2018). Economic valuation methods can be market-based, non-market-based valuation methods, as well as value transfer (Xiang 2018), and different valuation methods are suitable for different costs and benefits of gully erosion projects. In this study, both market-based and non-market-based valuation methods were used to analyse the control project costs and benefits.

2.2 Geography of the Research Area and Methodology

2.2.1 Location and Extent

Gombe Metropolis is located between latitude 10° 14' 30"N to 10° 20' 30"N and longitude 11° 07'E and 11° 14'E. It has a common boundary with Akko LGA in the south and west; Yamaltu-Deba to the east and Kwami to the north, as a metropolis. The metropolis occupied a total land mass of about 45Km² (Ibrahim and Jauro 2016).

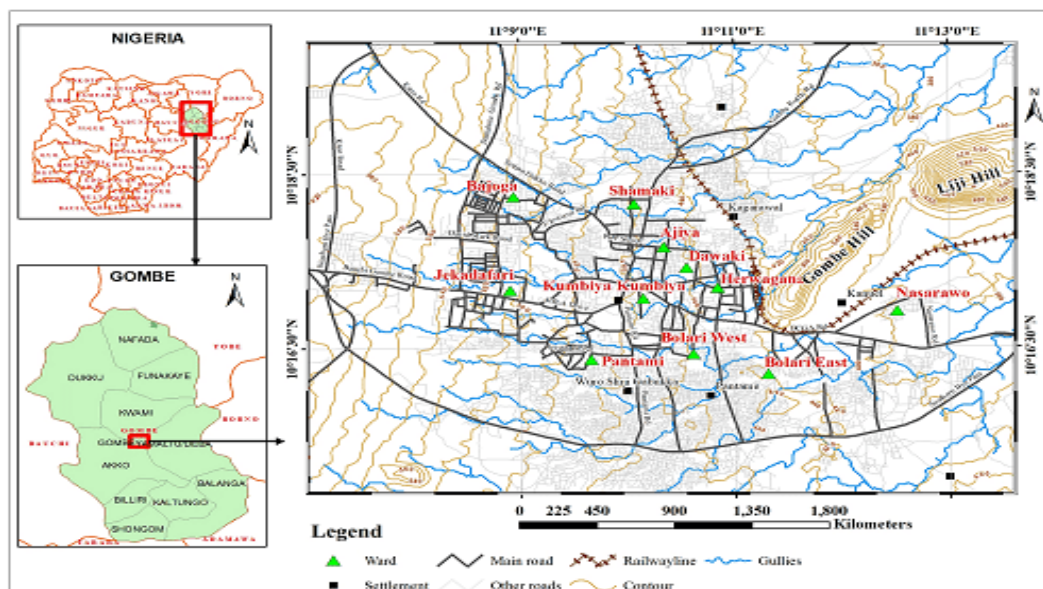


Figure 1: Map of Gombe Metropolis

Source: GIS Map Services (2022).

3.0 Material and Method

3.1 Data required

The data for this study included data from field work and other primary and secondary sources. Data about the different benefits acquired as a result of the selected projects by project-affected persons were also obtained, as well as the estimated cost of the benefits in terms of monetary value. Acquisition of the information about the discounted cost of the projects as well as the estimated cost of the benefits of the project, is important in the analysis of cost-benefit variables such as the cost-benefit ratio (CBR) and the net present value (NPV).

3.2 Sources of Data

The sources of data for this study were derived from researcher-constructed data, commonly referred to as primary data, and documented sources, otherwise referred to as secondary sources of data. The primary data included data obtained from the gully control project sites, through classification and analysis of satellite images, in-depth and key informant interviews as well as interactive sessions with sampled project affected persons and other people living around the gully sites whose properties were directly or indirectly affected as a result of the control project and also with some officials of the State Ministry of Environment, the LGA Environment Department, the NEWMAP and officials of other relevant agencies.

3.3 Sampling Size and Sampling Techniques

This study covered only gully erosion control projects where standard resettlement action plan was incorporated in the project planning, to conduct cost-benefits analysis which was the main aim of the study, the followings gully sites were purposively selected: therefore this study only cover the following gully sites:

- i. GSU-Mallam Inna-Kagarawal Gully site. (known as GSU Project site)
- ii. FCE(T)-Juro Abare-Jauro Kuna-M/Inna-Wuro Kesa-Tukulma (known as FCE(T) project site).

3.4 Cost-Benefit Analysis Model

Cost-Benefit analysis model used to analyze the net present value and benefit cost ratio criterion chosen for this study as follows:

- a. Net Present Value (NPV): This represents the difference between the total discounted benefits minus the total discounted costs; thus, the Net Present Value (NPV) is the most widely used criterion in cost-benefit analysis. It determines the present value of net benefits (or costs) by discounting the streams of benefits (B) and costs (C) at the rate (r) set at 3.5%, arising between the present ($t=0$) and t periods into the future. The NPV is thus calculated using the following equation:

$$NPV = \sum_{t=0}^t \frac{B_t - C_t}{(1+r)^t} = (B_0 - C_0) + \frac{B_1 - C_1}{(1+r)^1} + \frac{B_2 - C_2}{(1+r)^2} + \dots + \frac{B_t - C_t}{(1+r)^t} \quad (1)$$

- b. **Cost Benefit Ratio (BCR):** Benefit–Cost Ratios (BCR) are determined by dividing the total value of benefits by the total value of costs. The BCR is thus calculated using the following equation:

$$BCR = \frac{\left[\sum B_i / (1+d)^i \right]}{\left[\sum C_i / (1+d)^i \right]}; \quad \text{summed over } i = 0 \text{ to } n \text{ years} \quad (2)$$

Where: B_i = the project's benefit in year i , where $i = 0$ to n years

C_i = the project's costs in year i , where $i = 0$ to n years

n = the total number of years for the project duration/ life span

d = the discount rate.

3.5 Valuation of Benefits of the Control Project

In the valuation of benefit of action against gully erosion project, the costs of inaction represents the maximum level of benefit from action against land degradation (Mesfin et al, 2015). In this study, the theoretical maximum benefits of action referred to the cost of inaction against gully erosion problem in the area. The actual benefit of action, however, depends on the level of efficiency of the type of intervention or action in averting gully erosion menace and hence the level of reduction in the associated lives and property losses. For example, different gully erosion control measures have different levels of efficiency in controlling gully erosion. It is not also possible to realize all of the costs of inaction into benefits at a time for the fact that action or intervention requires both time and resources. Therefore, it is important to note that realistic assumptions will be used in estimating the benefits of action based on the market, non-market and value transfer valuation in calculating the cost-benefit analysis for this research work. Thus, for the purpose of this study, the benefits of action will be estimated as fraction of the costs of inaction using the following equations according to Mesfin et al (2015), where the fraction (λ) represents the rates by which cost of inaction is converted into benefits as follows:

$$BA_1 = n\lambda CIA_1 \quad (3)$$

$$BA_2 = n\lambda CIA_2 \quad (4)$$

Where:

BA_1 = value of avoided physical properties lost.

BA_2 = value of avoided economic trees lost.

λ = rate by which the factor causing the property loss is reduced at the time (t).

$n = t-1$, indicating that at the initial year of intervention, $n=0$ and hence zero benefit.

In economic terms, when BCR is less than 1.0, the costs exceed the benefits. Solely on this criterion, the project should not proceed. While, when BCR equals 1.0, Costs now equal the benefits, which means the project should be allowed to proceed, but with little viability, but when the benefits exceed the costs, i.e., when the CBR is greater than 1.0, then the project should be allowed to proceed.

3.6 Method of Data Analysis

In order to calculate the Net Present Value and Cost Benefit Ratio for the computation of Cost-Benefit Analysis, Microsoft Excel was used for this analysis.

4.0 Results and Discussion

4.1 Cost-Benefit Analysis of Sampled Gully Projects

Some selected gully control projects were used to analyse the cost-benefit of the control projects, given the fact that global best practice was applied in the project's execution. The Net Present Value (NPV) and the cost-benefit ratio are the main appraisal indicators used in this analysis. These are the commonly used decision criteria for determining the viability of a project (Gerald 2011). The NPV is defined as the present worth of the net benefits of a project.

In financial analysis, it is considered to be the present value of the net income stream accruing to the entity undertaking the project. NPV is mathematically expressed as:

$$NPV = \sum (B_t - C_t) / (1+i)^t = 0 \quad (5)$$

Where:

B_t is the gross benefits.

C_t is the total cost.

t is the time horizon = 30 years, and 'I' is the discount rate (Conceptually it is the discount rate, but during calculation the interest rate is taken) = 16.5% (0.165).

4.2 Net Present Value (NPV) of the Sampled Gullies

Table 1 presented the result of Net Present Value of the GSU gully projects. The result showed -4,578,284 as NPV for GSU gully project, while it was 137,672,712.12 for FCE gully control and the total benefit and cost of the gully control project for GSU was N2, 611,728,420 and N3, 058,889,487.7 respectively while that of FCE gully control was N10, 775,734,710 and ₦5,964,073,421.55 respectively. The NPV result here indicated a negative outcome for GSU gully erosion control project, meaning that the cost of the project using Engineering Method is higher than the benefit value that the project may provide. This shows that when comparing cost to benefit, the project is not worthwhile or viable as per as the NPV is concern, while it shown a positive result for FCE gully control project indicating that the cost of the project is less than the benefit that the control effort may provide. This simply means that the project control option was viable to be embarked upon.

The implication of this finding is that the decision makers shouldn't have gone ahead with the GSU gully erosion control project until a viable project control method alternative is explored. However, this finding is in direct contrast with perception of the communities whom are the main beneficiaries of the project, about 80% of the community member's interview indicated satisfaction with the project and the method adopted. This study also agreed with Post Humous, Deeks, Rickson and Quinton (2015) and Mwamburi and Maghanda (2021) who found the negative value of NPV on cost and benefit of gully erosion measures in UK, and cost benefit analysis of sustainable land and water management practices respectively.

Table 1: Calculated Net Present Value of GSU Gully Project

Gully	Bt	Ct	I	T	NPV
GSU	N2,611,728,420	N3,058,889,487.7	16.5% (0.165)	30yrs	-4,578,284
FCE(T)	N10,775,734,710	₦5,964,073,421.55	16.5% (0.165)	30yrs	137,672,712.12

Source: Data analysis (2024)

While for FCE gully erosion control project, the implication is that the decision makers will be recommended to go ahead with the project using the adopted engineering control method. Similar result was obtained in a study conducted by Ardianto (2011) on the cost benefit analysis of sediment management in Sutami Dam where he obtained a positive NPV in all the five alternative project he studied, (i.e all the cost of the benefit was higher than the cost of the project) with alternative project 4 and 5 having highest benefits value than 1, 2, and 3.

Comparatively, the result of Net Present Value for FCE gully project was positive while that of GSU gully project was negative, this means that engineering control method is more viable option for FCE gully erosion project, than that of GSU gully project.

4.3 Benefit Cost Ration (BCR) of the Sampled Gullies

Another decision criterion studied is the Benefit Cost Ratio. The BCR is defined as the ratio of the present value of the benefits relative to the present value of the costs more formally:

$$BCR = \frac{\left[\sum B_i / (1+d)^i \right]}{\left[\sum C_i / (1+d)^i \right]}; \quad \text{summed over } 1 = 0 \text{ to } n \text{ years} \quad (6)$$

Where:

Bi = the project's benefit value.

Ci = the project's total costs.

n/t = the total number of years for the project duration/ life span = 30 years

d/i = the discount rate/interest rate= 16.5% (0.165).

Table 4.9 presents the result of Benefit Cost Ratio (BCR) computed for GSU-Kagarawal and FCE (T)-M/Inna Gully control project. The result shows 0.85 as BCR for GSU gully project while it was 1.85 for FCE gully control project, the total benefit and total cost of the project are N2, 611,728,420.00 and N3, 058,889,487.7.00 respectively for GSU gully project, while it

was N10, 775,734,710.00 and ₦5,964,073,421.55.00 respectively for FCE gully project. The BCR result here indicated a negative outcome for GSU gully project while it was positive for FCE gully erosion control project.

This finding is similar with that of Ardianto (2011) who had negative BCR in all his five (5) project alternatives studied with only project alternative 2 has positive BCR, This indicates in his study that all the other four (4) project alternatives are not viable options except alternative two (2). Morongkon and Blignant (2019) also reported a benefit cost ratio of between 0.29 and 0.41 which indicates a negative BCR since the ratio was less than one (1).

The implication of this findings is that the project is considered undesirable or not viable for GSU gully control project and decision makers weren't expected to have gone ahead with the project without looking at all the available control options, this is because the cost of the project is higher in such a way that any increment in benefit gain may not sufficiently cover the cost of the control project, while the control method is considered to be viable option for FCE (T) gully control due to its positive BCR value, this was because the benefit of the FCE gully control project is higher than the cost of the project.

It's important to note that both the decision criterion of NPV and BCR in the study produced negative results for GSU gully erosion control project, meaning the total benefit is less than the total cost, while the study produced positive result for FCE gully project for both NPV and BCR indicating that the total project benefit is higher than the total cost.

Therefore, the general implication is that the method adopted by the GSU gully control project is regarded as not viable and not worthwhile, as far as Cost-Benefit analysis is concerned, while the implication of this study for FCE(T) gully control was that the project is considered desirable and also viable and decision makers are expected to go ahead with the project, this is because the cost of the project is less in such a way that any increment in benefit gain may sufficiently cover the cost of the control project., this assertion also agreed with the perception of the beneficiaries communities whom are fully satisfied with project implementation and the method adopted. It's also interesting to note that the GSU gully control project is an environmental problem solving project, where the entire project itself may be regarded as beneficiary to the community especially for environmental protection and sustainability, this explain why despite negative values of NPV and CBR, the communities are highly satisfied with project which is most important as the project is mainly for their benefit.

Table 2: Calculated Benefit Cost Ratio of GSU Gully Project

ITEM	Bt	Ct	I	T	BCR
GSU	N2,611,728,420	N3,058,889,487.7	16.5% (0.165)	30yrs	0.85
FCE (T)	N10,775,734,710	₦5,964,073,421.55	16.5% (0.165)	30yrs	1.80

Source: Data analysis (2024)

5.0 Conclusion and Recommendation

5.1 Conclusion



The two decision making criterion for cost-benefit analysis (NPV and BCR) used in this study showed varied result with GSU-M/Inna-Kagarawal having negative while FCE (T) gully project having positive NPV and CBR respectively. This implies that cost-Benefit analysis could be used in project planning for gully erosion control projects for the purpose of helping the decision makers in taking an informed decision about the choice of control method to be adopted during project implementation.

5.2 Recommendation

There is a need for the government at all levels, borrowers, and financial intermediaries to adopt a cost-benefit analysis model as part of the decision-making criterion for planning gully erosion control projects.

Government should leverage on more resources from funding/donor agencies, borrowers such as World Bank, the African development bank, Islamic development bank as well as draw more resources from the ecological fund to effectively control more gullies and tame their expansion, and ease the burden and threat they pose on the nearby communities.

There is a need for communities around these gully erosion sites to be sensitized and encouraged about the need for community effort in developing local gully control strategies and prevention of waste disposal inside the gullies.

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